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Effects of Sensory Deprivation

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Clinical Aspects of Perceptual Isolation

A relatively recent development in psychiatry has been the study of the effects of reduced perceptual and sensory stimulation. We have tried to secure the most rigid conditions of isolation consistent with reasonable physical comfort, by the construction of a suspended soundproof room (Smith & Lewty 1959) in which the insulated layout had a sound difference level rising to 82 dB at 10,000 c/s. Twenty-seven volunteers have spent varying periods in this room and their reactions were carefully noted. Twelve aspects of mentation were studied, inquiries being made each time the subject was visited, into thinking, affect, psychomotor activity, time assessment, body image disturbance, somatic symptoms and signs, irritability, sleep, dreams, appetite, delusions, and hallucinations.

Our observations and records outline a fairly clear-cut chain of events. At first most volunteers show a tendency to sleep, some for an unduly long time. Then follows a period of growing agitation, tension and restlessness. Disturbed thinking, particularly obsessional, occurs about this stage, and most subjects experience panic which makes them leave the room. A 20-year-old girl showed none of the usual premonitory signs (e.g. restlessness) until about the eightieth hour; then very quickly she became restless and developed the idea that she was locked in the room. This, she knew, was untrue, but the idea persisted and increased in intensity together with a feeling of distress. This miniature and experimental obsessive-ruminative state developed over an hour or so; and the ensuing anxiety and panic were only relieved when she pressed the plunger and let herself out.

Discussion

Published results of this type of experimentation can be divided into two groups. Some workers (e.g. Bexton *et al.* 1954, and Goldberger & Holt 1958) have described well-marked sequelæ to sensory deprivation, including disturbances of thinking, imagery, time appreciation, and delusional and hallucinatory phenomena. Others, such as Vernon & Hoffman (1956), found virtually no sequelæ. Most of this work can be criticized on the ground that the conditions of sensory deprivation, particularly the degree of silence, have not been measured. The experiments of Vernon & Hoffman are especially interesting because their chamber was a 'floating room' which was measured to an 80 dB sound loss – conditions comparable to ours.

Our two volunteers who left the room after five hours were anxiety-prone worrying personalities. The first obtained a score of 18 and the second a score of 20 on the Maudsley Medical Questionnaire, which tends to confirm their neurotic tendencies. Indeed, if Eysenck's (1947) conception of the dysthymic personality is accepted there is a close correlation between this group and inability to stay in a room for any unusual length of time. In general, these results fall halfway between the multiplicity of symptoms recorded by Goldberger & Holt (1958) and the entirely negative findings of Vernon & Hoffman (1956).

'Demand characteristics' of the experimental situation, e.g. the subject's instructions, his preknowledge and expectations, may play a large part in such result discrepancies and efforts were made to keep these factors constant.

The experimental situation itself can be used for many and varied investigations. For example, two volunteers who were complaining of disturbed, disjointed, and obsessive thinking (and whom one confidently expected to retire very soon) were able to go on for another 36 hours after carrying out a progressive matrix; it seemed as though the discipline required to marshal thoughts and to concentrate had re-established their normal thinking pattern.

We have encountered no post-isolation phenomena but our observations do not support

the idea put forward by Rosenzweig (1959) that the method produces an experimental model of the schizophrenic syndrome superior to the 'model psychosis' of mescaline or L.S.D.

PERCEPTUAL ISOLATION AND SCHIZOPHRENIA

Subsequent to our work done on the 27 volunteers, we decided to follow Harris's work (1959), on sensory deprivation associated with schizophrenia. Harris took 12 subjects and put them in a sound-proof box belonging to the B.B.C., isolating them for periods varying between half and eight and a half hours. Three main results were produced: (1) That schizophrenics tolerated it remarkably well. (2) That all under-estimated time. (3) That their hallucinations were less vivid and troublesome during the time in the cubicle.

Our schizophrenics had been ill for at least five years. They were all typical long-term nuclear or process schizophrenics. We decided to examine them according to the average total deprivation that we had found for normal people i.e. 29·24 hours in the case of men, and 48·70 hours in the case of women. Since results at the end of this time were non-existent or negligible, it was decided to continue much longer than originally planned. We examined their responses both during and after isolation to the twelve aspects of mentation which we had studied while the normal volunteers were in. Varying psychological tests, and EEGs, were done before and after the period of isolation. They were rated for ten days previously on a Malamud-Sands scale (Smith *et al.* 1961).

Results

(1) From a clinical point of view the changes were negligible. There was probably some reduction in hallucinatory activity although it was impossible to be certain of this. (2) The psychologist found an improvement in cognition using a battery of 8 tests. He also thought there was an improvement in the M.M.P.I. and a definite increased time in Jung's Word Association test. (3) The EEGs showed more widespread slowing up to one hour after deprivation with theta and delta conspicuous. There was no paroxysmal or focal activity.

There was no doubt that schizophrenics could tolerate this type of anxiety-provoking stress very well. Are we simply enhancing one of the natural defences used by schizophrenics, i.e. withdrawal in the face of anxiety or anxiety-provoking situations, or is it another example of schizophrenic indifference in a situation which causes anxiety in normal people?

Although clinically there was little apparent change, the psychological testing seemed to support the results of Azima & Cramer-Azima (1956) who, in mentally disturbed individuals, including schizophrenics, after 120 to 144 hours in a 'single hospital room containing all facilities and situated farthest from the centre of the ward', found an increase in motivation, socialization and self-assertiveness.

Normal subjects find increasing need for and attempt to obtain extrinsic physical and social stimuli. Schizophrenics have no such need and make no effort to obtain such stimuli.

One partial unifying theory would be that of McGhie & Chapman (1961). According to them, schizophrenia is basically an illness in which cognition is impaired with absent or disturbed control over attention, a task of the reticular system. As a result, the cortex is flooded with irrelevant information, a theory in harmony with recent studies on sleep, arousal mechanisms and the nature of consciousness. Theoretically, therefore, conditions of perceptual isolation should diminish the amount of irrelevant information the cortex is dealing with in chronic schizophrenics, and it may be that our paucity of results would fit in with this concept, i.e. clinically negligible changes but on psychological testing, some improvement, even in these long-established mental illnesses.

PERCEPTUAL ISOLATION AND PSYCHOTOMIMETIC DRUGS

Cohen *et al.* (1960) administered phencyclidine to volunteers under sensory deprivation conditions: although the subjects reacted normally to phencyclidine (a piperidine compound used in anæsthetic and as an abreactive agent by Davies, 1961) with somatic and psychological sequelæ, when phencyclidine was combined with sensory deprivation the phenomena previously experienced, with the drug only, were either very much reduced or completely absent.

Normally, when phencyclidine is administered there are early and prolonged symptoms of anxiety, thinking difficulties, illusional, delusional and hallucinatory phenomena and often a feeling of displacement (Meyer *et al.* 1959).

We obtained 6 volunteer student nurses to take 10 mg phencyclidine by mouth, to observe the effects of this and then, a week or so later, to take the same dosage under conditions of sensory deprivation. All the subjects on the first occasion experienced the usual somatic and psychological symptomatology now well known with phencyclidine. Emotional lability with anger or depression and sometimes weeping and odd behaviour were also observed, with disorientation. A week later, under conditions of maximum sensory deprivation, virtually nothing happened to most of the

volunteers at the time of taking the phencyclidine, and there appeared no doubt that we were in fact confirming the results of Cohen *et al.* (1960). There were some discrepancies, however:

For example, one student nurse, aged 21, who had received 10 mg phencyclidine, had many physical and mental symptoms, the predominant mental feeling being that he was in a bubble and could not get out. This was extremely unpleasant, and he was frightened and at times verged on panic. Consequently he became slightly dizzy with paræsthesia in all limbs, the effect lasting about forty-eight hours. Ten days later he was again given 10 mg phencyclidine, this time under sensory deprivation conditions. The mental symptoms were very much less and he experienced no delusions or illusions such as he had before. The physical symptoms, however, of tiredness, dizziness, particularly postural in type, and numbness of lips and extremities, were very much greater and lasted at least seventy-two hours.

We have observed a similar phenomenon with two volunteers who had L.S.D. 25.

In other words, there was a definite implication that conditions of sensory deprivation seemed to prevent the usual psychological effects associated with the particular drug, suggesting that for these phenomena to occur definite sensory inputs need to be present. It may be that these sensory inputs are not necessarily exteroceptive in type. One student nurse, who became noisy and excited even before the test, continued to talk to himself throughout; he was the only one of the group who complained subsequently of similar sensations to those he had experienced when he was out of the room. He was, as it were, making his own input by his own restless behaviour and conversation to himself.

In all the theories put forward to explain some of the phenomena resulting from sensory deprivation, the factor of social isolation *per se* must be considered. At present we are trying to find enough suitable people to carry out isolation studies in pairs to see whether human verbal contact can prevent or postpone such isolation phenomena occurring. Davis *et al.* (1961) have indicated that such social contact does not prevent the effects of sensory deprivation occurring but does ameliorate them.

An endless variety of experimentation could be carried out with such an excellent and measured tool as a properly constructed silent room. Results so far, from many places (Leiderman *et al.* 1958), suggest that many clinical states (e.g. nocturnal confusions of old age, post-cataract-operative delirium – 'black patch delirium', deafness and paranoid symptoms) and many other neurotic and sometimes psychotic episodes occurring in people immobilized for long periods (e.g. severe sensory polyneuropathies, cardiac and orthopædic cases) can have some explanation in the language of sensory deprivation. Even the accidents occurring in some long-distance motor drivers have been partly attributed to the lack of sensory stimulation, although obviously this can be only one of many factors. It is, however, salutary to remember that 'the results of deprivation studies will continue to have limited practical application until the field is more systematically investigated' (Thorpe 1961).

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Sensory Deprivation Phenomena: Critical Review and Explanatory Models

'*Sensory deprivation* is the term applied to various experimental techniques designed to isolate the subject from his natural environment through the elimination, reduction, or stereotyping of sensation from vision, hearing and touch.' (Solomon *et al.* 1959.)

The definition deliberately excludes two groups of phenomena, emotional and maternal deprivation, and developmental deprivation. There are three main sources of information about sensory deprivation: (1) The anecdotal: reports of experiences in situations not specifically designed as experimental, e.g. polar exploration, submarining, high altitude flying, mountaineering, prison, concentration camp and escape. Summaries of this literature are available in Sedman (1961) and Solomon *et al.* (1957). (2) The clinical: reports of experience or behaviour of patients in which 'deprivation' is an aspect of the wider clinical situation, e.g. amputation (Kolb 1959), eye surgery (Ziskind *et al.* 1960), poliomyelitis (Mendelson *et al.* 1958), deafness and orthopædic procedures (Jackson *et al.* 1962). Evaluation is difficult because it is often unclear whether there

was any clouding of consciousness. A critical review of this area is needed. (3) Experimental: work on normal subjects was begun in 1951 by Heron, Scott, Bexton, Doane, Mahatoo and others at McGill University under Professor D O Hebb.

At least ten American centres are at present engaged on research. In England some work was done in the Maudsley Hospital and Smith & Lewty published their first paper from Lancaster Moor Hospital in 1959. American research is now largely motivated by problems of space travel. A recent symposium on space flight devoted several papers to the topic (Flaherty 1961).

Variables

Three complexes of variables have been used:

(1) *Absolute reduction of quantity of input*, 'profound sensory isolation' (Shurley 1960): In Shurley's procedure the aim was maximum achievable reduction of ambient physical stimuli, plus the maintenance of a constant level of those stimuli impossible to eliminate. The subject was immersed in a large tank of slowly-flowing water and instructed to inhibit all unnecessary body movements. A microphone and tape recorder made audible, and kept a recording of, all comments by the subject. Similar immersion procedures have been used by others (e.g. Lilly 1956). The iron lung has been used by Solomon *et al.* (1957), and Wexler *et al.* (1958).

(2) *Alteration of patterning of stimulation:* Here the procedure has been to limit the variability of the sensory input by goggles admitting only translucent light and not permitting object perception, and by a meaningless, random sequence of blanketing sounds. Smith & Lewty (1959) used a room suspended on nylon cords with a sound pressure level difference of 82 dB at 10,000 c/s. Subjects wore translucent goggles and padded fur gauntlets. Similar environments were provided by Bexton *et al.* (1954), Scott *et al.* (1959), Vernon & Hoffman (1956), Vernon *et al.* (1958), Grunebaum *et al.* (1960), and Goldberger & Holt (1958). Davis *et al.* (1960) used the tank type respirator with vents open and a semi-darkened room, cardboard cuffs over arms and legs, and constant repetitive auditory stimuli from motors and random flashing of lights.

(3) *Monotony:* Variables within this category may be separated from (2) because of the emphasis on imposed structuring and affective factors of interest and attention. Here the environment is characterized by absence of change. There is normally-patterned vision of highly restricted environment. Several workers have noted the relevance of earlier studies of monotony and of vigilance (Mackworth 1950).

Absolute reduction of sensory input is clearly impossible to achieve. Manipulation of exteroception alters relative thresholds and proprioceptive input, which is largely beyond control, becomes dominant.

Number and Type of Subjects

Experiments lasting perhaps eight hours or fourteen × twenty-four hours need two experimenters for each subject. Published data therefore refer to single cases or to small groups, usually less than 20 persons. Most subjects have been paid volunteers or members of the armed services, described as normal. However, volunteers for such experiments are not a random sample. It is probable that such groups contain persons likely to have merited a diagnostic label had they presented as patients at a psychiatric clinic. In several instances the form of instruction to subjects was indefinite as to expectation. Instruction as to time has varied from the definitive to the completely uncertain and indecisive.

Effects of Sensory Deprivation Experiences

(1) *Panic, fear, anxiety:* Panic occurred in 2 of the 17 subjects of Wexler *et al.* (1958). Anxiety or panic was given as the reason for leaving isolation by 16 of 19 subjects in Smith & Lewty (1959); 6 included somatic symptoms and 3 of them gave panic alone as the reason. However, panic is rare and fear and anxiety are not often mentioned. Those investigators who suggest some regularity in appearance of symptoms tend to place great anxiety and panic at the end of the sequence (Wheaton 1959, Vosburg *et al.* 1960).

(2) *Affective level:* Smith & Lewty (1959) report that one of their subjects had a definite depressive reaction. Shurley's subject (1960) after three hours showed great labilities of mood, and Scott *et al.* (1959) observed a childish sense of humour, irritability and annoyance.

(3) *Perceptual changes:* Changes in the perceptual field were the first to be reported in the experiments of the McGill group. The subjects of Doane *et al.* (1959) experienced apparent movement independent of movement by the observer, and part of a moving figure appeared to trail behind the rest. The room appeared to alter in size and contour, pronounced negative afterimages appeared and colours seemed bright and highly saturated or luminescent. Black figures on a white ground gave rise to subjective colours. There were consistent changes in size-constancy experiments, significant differences in figural

after-effects, autokinetic phenomena, colour adaptation and after-movement images. There were no changes on other perceptual tests. On a tactual form discrimination test the deprived subjects deteriorated significantly. Vernon & Hoffman (1956) reported no increased saturation or any lack of three-dimensional perception. No significant effect on depth perception was found by Vernon *et al.* (1958) but colour perception was affected especially after forty-eight and seventy-two hours.

Grunebaum *et al.* (1960) reported that straight lines appeared to move, to change shape and size, and haloes to develop. Freedman *et al.* (1961) after eight hours of deprivation found perceptual effects comparable to those reported after long periods of deprivation. Freedman and Greenblatt compared 'the effects of prolonged exposure to strong diffuse light with blackout conditions. Subjects experienced visual disturbance in either situation despite apparently large differences in quality and quantity of stimulation' (*see* Freedman *et al.* (1961). Held and Freedman (*see* Freedman *et al.* 1961) compared the effects of extrinsic visual 'noise' with those of diffuse and blackout fields. Similar but far greater changes in apparent visual speed followed from noise than from homogeneous stimulation. Held & White (1959) had sought to make more precise a finding of Heron *et al.* (1956), and affirmed that speed of moving objects was markedly underestimated after eight hours of deprivation which included patternless visual stimulation, but that the effect was increased by exposure to a 'noisy' visual field. Where the field was hyperstable the effect was overestimation. Walters & Quinn (1960) after 30 minutes' deprivation found both initial latency and autokinetic effect enhanced by deprivation.

(4) *Perceptual motor skills:* Significant decline in rotary pursuit ability was recorded by Vernon *et al.* (1961), but only after forty-eight hours of deprivation. Neither error nor time scores on a pencil maze were significantly changed. Gross motor skill, in a rail-walking test, was adversely affected, especially after seventy-two hours. The findings of Scott *et al.* (1959) with mirror-tracing contradict those just mentioned. Zubek *et al.* (1960) report significant decline in dexterity.

(5) *Time:* Time was usually overestimated by a half-hour to three hours and direction of error appeared to change during deprivation (Smith & Lewty 1959). Cohen *et al.* (1961) report that only one subject (of 10) grossly misperceived the time. Under-estimation is reported by Shurley (1960) and by Walters & Quinn (1960) but there was no consistent pattern in the reports of Wexler *et al.* (1958). With the exception of Goldberger & Holt (1958), few who included time as a variable paid attention to the crucial distinction between felt time and cognitive time. Petrie *et al.* (1960) discuss the relation of satiation to the subjective evaluation of time. Recently Banks & Cappon (1962) report almost universal underestimation but no clear relationship with feeling about the passage of time.

(6) *Changes in level of consciousness:* In all the lengthy intervals of deprivation subjects passed varying periods in sleep. The Smith & Lewty (1959) subjects, staying more than six hours, all slept more at the beginning. Shurley's subject (1960) had a sequence of brief two-minute naps, awaking with an eerie feeling that he had been 'out of this world'. Graybiel & Clark (1961) suggest a relation between ability to sleep and resistance to ill-effects of deprivation.

(7) *Level of attention, restlessness, inability to concentrate:* All but 2 of the 20 subjects used by Smith & Lewty (1959) became agitated and restless, both subjectively and objectively. Only 2 subjects were irritable or aggressive. Shurley's subject (1960) could not concentrate. Similar effects on attention are listed by Bexton *et al.* (1954) and Freedman (1961*b*).

(8) *Cognitive efficiency, problem solving, abstract thoughts:* In all (18) subjects who stayed for any length of time there was distortion of thinking. In several, concentration was considered to be completely lost (Smith & Lewty 1959). Subjects in Davis *et al.* (1960) reported feelings of mental clouding, but test results on block design and hidden figures showed no significant differences. The deprived group showed significant ($p < 0{\cdot}05$) impairment in the Wechsler digit symbol test. Lack of clarity in thinking, and difficulty in organizing thoughts occurred in all of the 18 subjects of Scott *et al.* (1959). This latter difficulty was progressive. By contrast the significant decline in six of the cognitive tests was not progressive. Little support for deteriorating effects came from Vernon & Hoffman (1956). Using a learning test they found improvements. Zubek *et al.* (1960) after seven days of deprivation found no significant differences in verbal and numerical tests. Recent memory was significantly impaired. Logical deductions alone showed significant impairment in the group of Goldberger & Holt (1958).

(9) *Body image disturbance:* A minority of researches have reported this. Seven subjects in Smith & Lewty (1959), mostly towards the end, reported changes – 'my arm is like a ton weight and feels fatter than my body'. Reporting the

early McGill work, Bexton *et al.* (1954) had comments of 'strangeness' in the body, and of two bodies as overlapping in space. Goldberger & Holt (1958) and Cohen *et al.* (1961) also reported body image disturbances.

(10) *Imagery:* The McGill workers were the first to evoke 'hallucinations' by experimental interference with perception under sensory deprivation:

(*a*) Auditory: Auditory phenomena have been infrequently reported. Shurley's single subject (1960) heard a small voice, at which he shouted. One of the subjects in Freedman *et al.* (1962) reported 'I heard a muffled conversation. . . .' He heard music and then the 'crash of the highest pile of boxes in the world'. Goldberger & Holt (1958) report quasi-hallucinatory auditory phenomena which were experienced after eight hours by some subjects as external. It is difficult to evaluate these auditory phenomena. Some may in fact be illusions or delusional percepts. Under the conditions of sensory deprivation clear limits as to what might be heard are not available. A physician heard the gliding sound of his own large joints. By the layman this experience might well have been misinterpreted.

(*b*) Visual: All Shurley's 11 subjects (1962*a*) experienced some form of mental imagery – from daydreams to fully projected hallucinatory experiences. Several images were three-dimensional, in colour and completely projected. Shurley's single subject (1960) saw 'an inverted V in brilliant blue and white flame moving through dark space'. Lilly (1956) relates his own experience: 'After two and a half hours forms . . . appear . . . strangely-shaped objects with self-luminous bodies; a tunnel whose inside space seemed to be emitting a blue light. . . .' Six subjects of Davis *et al.* (1960) had hallucinations or illusions. Vernon & Hoffman (1956) and others have reported the absence of hallucinatory experiences.

Several researchers have varied the conditions from complete black-out to translucent goggles. Doane *et al.* (1959) found that 8 of 11 subjects wearing these had hallucinations. Of 2 who wore opaque masks one developed hallucinations, but with translucent goggles both had vivid hallucinations. All 5 of those who had most persistent hallucinations with goggles, when put in complete darkness reported an immediate increase in vividness. Vernon *et al.* (1958) found that movement allowed resulted in many more 'hallucinatory' phenomena. Freedman *et al.* (1962) depriving for 8 hours with (i) goggles, (ii) blackout, obtained images, usually coloured and vivid, often in great detail. Later these three workers (Grunebaum *et al.* (1960) argued that non-patterned stimulation was the essential cause of the visual phenomena. Vernon *et al.* (1961) suggested that lack of movement is the essential additional 'causative' factor, but Courtney *et al.* (1961) found no relation between amount of movement and imagery.

(*c*) Kinæsthetic, tactile, gustatory and olfactory imagery: Four subjects are reported by Hebb (1961) as experiencing kinæsthetic and somæsthetic phenomena. Davis *et al.* (1960) report tactile and olfactory experience. Shurley's subject (1960) 'strongly felt that I was stirring with my left leg and it was a spoon in an iced tea glass, just going round and round'. A subject in Freedman *et al.* (1962) said there was 'a great odour around me . . . like garbage or something'. There were reports of sensations of falling and floating in air.

(11) *Sensitivity feelings:* Some experimenters reported experiences which may loosely be described as sensitivity feelings or as paranoid in character (Freedman 1961*b*, Davis *et al.* 1960, Shurley 1960).

(12) *Somatic complaints:* Smith & Lewty (1959) had three cases of such complaints. Davis *et al.* (1960) found more feelings of somatic complaints in the deprived group. Wexler *et al.* (1958) classifies these statements as pseudo-somatic delusions. Graybiel & Clark (1961) speak of 'Zero G asthenia' and all three subjects complained of weakness. Mendelson *et al.* (1961) report many somatic complaints.

Temporal Sequence of Deprivation Phenomena

Several workers have claimed a temporal order (Smith & Lewty 1959, Lilly & Shurley 1961). Wheaton (1959) lists a pattern of eight responses in a 'sensory isolation syndrome'. Shurley (1962*b*) denies any such regularity.

Duration of Phenomena

One of the initially surprising findings is the reports of the post-isolation phenomena. Heron *et al.* (1956) found some effects persisted over twenty-four hours. Freedman (1961*a*) considered effects lasted on average about five minutes. Smith & Lewty (1959) were aware of no post-isolation phenomena. Doane *et al.* (1959) found that gross visual disturbances disappeared in half an hour. Scott *et al.* (1959) found test behaviour impaired two and a half hours after isolation, Bexton *et al.* (1954) obtained reports of headache and fatigue and mild nausea for twenty-four hours after isolation. Lilly (1956) had a post-isolation sense of refreshment. Goldberger & Holt (1958) reported varied sequelæ.

Therapeutic Effects

Several workers have claimed therapeutic benefit from sensory deprivation. Harris (1959) considered that hallucinations in 12 schizophrenic patients were reduced in vividness. Smith *et al.* (1961) achieved few positive results with six schizophrenics under conditions of lengthy deprivation.

Sensory Deprivation as a Dependent Variable

Most research has clearly been exploratory in character, and few workers have taken some

objective aspect of sensory deprivation as a dependent variable (Silverman *et al.* 1961, Grunebaum *et al.* 1960, Wexler *et al.* 1958, Cohen *et al.* 1961, Goldberger & Holt 1958, Solomon *et al.* 1961, Hull & Zubek 1962).

Theoretical Explanations

There has been no dearth of theorizing. These formulations, following current fashion, are often presented as models. Several have drawn on recent knowledge and speculation about the reticular formation. Because of 'the strategic location' of the ascending reticular activating system at the cross-roads of input and output systems, 'it is able to sample and monitor all such activities. . . . If one deprives the reticular system of its sensory input, it meets an unfamiliar situation. . . . It is believed this change accounts for the unusual features of sensory deprivation . . .' (Lindsley 1961). Viewing the brain not as a mere receiver of input, but as having some self activity, the adaptive quality of normal brain function depends on input to maintain this reality-adapted activity. Interference with input allows function to continue but becoming increasingly out of phase. Reduction of external stimuli allowing endogenous activity in end-organs, e.g. in the eye, to fire back into the cortex has been suggested as explaining some of the deprivation data.

Psychological theories are of two types: Those deriving from (1) academic psychology, e.g. from theories of the motivational effects of exteroceptive stimulation (Kubzansky & Leiderman 1961), or from theories of perception and the disruption of the process by which one monitors and corrects the model and strategies used in dealing with the environment (Bruner 1961); (2) the psychoanalytic theory of ego autonomy as derived from Hartmann, Erikson and from Rapaport; the latter has suggested (1958) that in the absence of external stimulation the ego becomes unable to maintain its autonomy from the id and the effectiveness of ego structures in controlling id impulses may be impaired. None of these theories is satisfactory, if for no other reason than that it is not clear what is the true nature of the phenomenon to be explained. Others do not permit of experimental verification.

Conclusion

(1) Large groups of subjects cannot be expected in researches of this type, but numbers and range have been limited. (2) Sufficient data are not available about essential characteristics of the experimental subjects. One cannot exclude the conservative hypothesis that some at least of the dramatic findings have explanations not at all specific to the conditions of deprivation. (3) A farrago of variables with minimal control has been included in the term sensory deprivation. Only recently have workers begun to attempt experimental discrimination between social and sensory deprivation, or to distinguish between (*a*) experimental variables, (*b*) personality variables, (*c*) interaction variables and (*d*) procedural variables. Situations of high uncertainty or defined goal have not been distinguished, nor have those with in-group members or paid volunteer strangers. (4) Published research reflects the emphasis on content characteristic of dynamic psychiatry and psychology and ignores the phenomenological approach. Much of the published interview data or listing of symptoms is of limited value. Nothing is said about the formal qualities of the experience and one cannot decide whether it is an hallucination or a pseudo-hallucination, a delusional percept, a delusion-like idea, an overvalued idea or a delusional notion. (5) Except in one or two cases there has been no replication. (6) There has been a tendency to seek theoretical explanations of the often inconsistent findings in the speculative areas of neurology, communication theory, psychoanalysis and perceptual theory without first considering the resources of more conventional formulations. There has also been a tendency to accumulate supporting evidence from other fields, e.g. maturational studies, ignoring the logical fallacies involved. Pseudo-precision at too early a stage is to be avoided, but a little of the rigour of research into sleep deprivation would be welcome.

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Preparatory Set as a Factor in the Production of Sensory Deprivation Phenomena

As Dr Smith and Mr Kenna have described, a large number of investigators have demonstrated that under a variety of so-called 'sensory deprivation' conditions many subjects report apparently unusual experiences and show changes in their performance of psychological tests. Of equal interest, perhaps, is that other investigators have *not* elicited such behaviour. To some extent this has doubtless been due to different experimental conditions, and Ruff *et al.* (1961) have outlined relevant variables. There is a need for the establishment of some base-lines before further research can be assessed in perspective. The modest pilot study to be reported here is part of a programme of 'ground-clearing' work.

Using ourselves as subjects a series of eight-hour sessions under various conditions of deprivation were undergone in Dr Smith's sound-proof floating chamber at Lancaster Moor. We found the conditions pleasantly relaxing but unproductive of any unusual perceptual, cognitive or affective experiences. We decided that this might well be due, among other factors, to our somewhat sceptical preparatory set. A survey of the literature showed that several writers have mentioned the possible importance of subjects' suggestibility, and Kandel *et al.* (1958) demonstrated that the visual imagery reported by subjects could be influenced by giving them 'loaded' instructions. Recently Jackson & Kelly (1962), in a study published since the present work was undertaken, have similarly shown that unusual perceptual experiences are reported quite rapidly after suggestion. It would seem possible, therefore, that a proportion of the 'S.D. phenomena' previously reported was not necessarily due only to the S.D. experimental conditions *per se* but to the nature of the subjects' expectations.

Objects

The primary aim of this study was to find whether subjects' expectations or set with regard to 'sensory deprivation' were related to their subsequent reports and test performances. It was hoped that information might also be gained regarding: (1) The association between 'S.D. phenomena' and personality variables. (2) The minimum time necessary under S.D. conditions for the elicitation of reports of unusual experiences. (3) The possibility of facilitating such reports by the use of indirect suggestion. (4) The psychiatric relevance of 'S.D. phenomena'.

Experimental Conditions

Subjects were required to lie on a couch in a quiet laboratory with an observation screen. They wore translucent goggles (which admitted light but not form) and padded headphones through which was transmitted random noise (static). Illumination was provided by a 100 watt bulb in an anglepoise lamp shining directly on to the goggles from a distance of 4 ft, the room being otherwise in darkness. The level of headphone noise was adjusted to be subjectively comfortable for each subject. Its purpose was to mask ambient sound and, as in the case of the light, to provide non-patterned stimulus. Such a set-up is similar to those employed in many of the classic studies.

Psychological Tests

It seemed desirable to use tests of those functions in which performance has been shown to change after exposure to S.D. conditions. Where possible the actual tests used in some previous studies were employed. Many previous batteries, however, seemed to have been inordinately long. The use, for instance, of Rorschach, T.A.T., M.M.P.I. and W.A.I.S. not only introduces or heightens the

effects of such variables as fatigue; it presupposes that S.D. effects last for several hours. Two parallel batteries were constructed for the present study which required less than twenty minutes each. They included tests of: Immediate visual memory (Benton Visual); Immediate auditory memory (Digit Span Forward and Back); Visual Illusion (Müller-Lyer); Visual constancy (matching discs); Arithmetic problems; Speed and accuracy in checking; Learning/Rigidity (Wechsler Digit Symbol).

Subjects

Experimental subjects were normal volunteers of above average intelligence, being thus comparable with those used in the majority of the classic studies. They included 10 men and 10 women with an age range of 19 to 41 (mean age 28·6). Seven were undergraduates reading psychology or medicine, 5 were taking a diploma in psychiatric social work and the remaining 8 were professional people including two psychiatrists, an audiologist, a secretary and university staff. A control group of 5 men and 5 women was composed of subjects from the same age and occupational categories as the experimental subjects.

Procedure

(1) Potential subjects were asked to complete a questionnaire regarding knowledge of and presumptions about sensory deprivation. On the basis of their answers to the questionnaire 10 subjects (Group A) were selected who believed that S.D. effects would be slight or would only occur after several days of S.D. A further 10 (Group B) were selected who considered that effects would be pronounced and would occur within the first hour of S.D.

(2) All subjects completed a Maudsley Personality Inventory.

(3) Each subject was given Battery 1. Tester, order of tests and conditions were constant.

(4) Group B subjects and 5 group A subjects were then allowed to reflect upon a 'paper summarizing the results of S.D. studies'. This indirectly suggested (by omission) that reports of unusual perceptual experiences were associated with intelligence, sensitivity and stability.

(5) Each subject was briefed. The conditions were described and he was asked to lie still upon the couch and to introspect, reporting aloud at intervals how he felt and immediately should he notice any perceptual change. Indirect suggestion was introduced by the experimenter's casual remark that it would be possible in theory for him to modify the experimental conditions during the session.

(6) Each subject was then taken into the laboratory, made comfortable upon the couch, the headphone noise level adjusted, and the tape recorder switched on. The experimenter then left the subject alone but observed him from the observation room. No stimulus changes whatsoever were subsequently introduced during the session.

(7) After a period varying from 40 to 60 minutes the subject was taken back to the testing room, and carried out Battery 2.

(8) He was then given a standardized interview aimed at intensive phenomenological description of his S.D. experiences.

(9) He completed Galton's questionnaire on 'mental imagery'.

RESULTS

Test Performance

It was presumed that under normal conditions a repetition of the majority of the tests in the present battery in an hour or less would show improvements due to practice effect. The control group was used to check the amount of improvement to be expected. The controls completed both batteries with an intervening interval of one hour during which they carried on with their normal occupations. As expected their scores on Battery 2 showed substantial improvements over those on Battery 1 except in the cases of the Müller-Lyer Illusion and the Benton Visual Retention. In these two tests the group means were the same on each occasion.

Group A's results showed a similar pattern. The improvement of mean scores Battery 1 to Battery 2 closely paralleled that of the control group. In only two tests did this differ; on those tests where the control scores were constant from Battery 1 to Battery 2, those of group A improved. Group B's results, on the other hand, were worse than on Battery 1. In all tests except the Mental Arithmetic this deterioration was not only relative but actual. Differences in test performance between groups A and B were thus in the expected direction for all tests.

Reports of Misperceptions and Imagery

Every subject reported subjective changes in at least two modalities. There were pronounced differences, however, between groups A and B, members of the latter reporting more experiences and of a more complex type (Table 1).

Reports were very similar to those in most previous studies. All subjects reported changes in the intensity and nature of the auditory stimulus.

Table 1
The number of subjects who reported experiences in the various modalities

	Group A	*Group B*	*Total*
Visual			
Change (brightness, flicker, &c.)	4	9	13●
Movement	3	8	11
Colour	4	7	11
Diffuse imagery (waves, clouds, &c.)	5	5	10
Pattern	2	4	6
Full imagery (people, places)	1	2	3
Auditory			
Change (tones, clicks, &c.)	10	10	20
Change of overall intensity	6	10	16●
Descriptive imagery (planes, trains, bees, &c.)	5	9	14
Heightened imagery (affectively toned – wind, musical tones, &c.)	1	2	3
Somatic			
Movement (of couch)	4	6	10
Body image disturbance	2	7	9●
Orientation (of couch or body)	4	4	8
Floating or 'disembodiment'	2	4	6
Touch (or pressure)	2	2	4
Smell	0	3	3
Taste	0	0	0
Suffocation and nausea	0	2	2
Changed time sense ('timelessness')	1	6	7●
Concentration impaired	5	4	9
Mood			
Depressed during S.D.	1	5	6
Elevated during S.D.	2	4	6
Depressed after S.D.	0	2	2
Elevated after S.D.	3	6	9
Admitted anxiety	0	5	5●
Aware of isolation (felt cut off, deserted)	3	5	8
Believed someone in room at times	4	5	9
Experience felt to be pleasant	6	3	9
Experience felt to be unpleasant	0	6	6●
Experience felt to be neutral	4	1	5

●Differences between groups significant at 0·05 level (single tail test)

Two of group B felt that the intensity had become so high as to be painful. Imagery (of trains, planes, bees, kettles, &c.) was commonly reported, but usually in a descriptive or analogous sense.

As in the classic work reported by Heron (e.g. 1961) visual experiences tended to develop from spots of light or dark lines to apparent changes in illumination to geometrical patterns and then (in 3 cases only) to full-blown and unusually vivid imagery.

Reported body-image changes or general kinæsthetic illusions were not only more numerous but more vivid than had been anticipated. Only two subjects reported nothing in these categories. The most common sensation reported was the simple one that the couch was being shaken or knocked. Almost as common was the impression that the position of the couch or of the subject's body upon it had been altered without him being aware of the change as it took place. Both these experiences were reported by members of each group. Significantly more group B than group A subjects reported body-image disturbances – limbs warmer, colder, lighter or swollen.

Interviews

The main finding derived from the intensive phenomenological interviews was that it was possible to define all the perceptual phenomena reported in terms of normal psychological mechanisms.

(1) Reports of simple stimulus 'changes' were probably responses to entoptic phenomena. Next were responses to minute but actual changes in conditions, changes which would normally be subliminal but which were noticed and responded to in the experimental situation because of heightened awareness (arousal) and directive *attention*. This itself is of course closely related to set. Subjects were, firstly, prepared to notice small stimulus changes and, secondly, had nothing else to do but notice them, lacking the distraction of attention-gaining meaningful stimuli.

(2) The next level of complexity of reports was in terms of verbalized description by analogy. 'It sounds like an engine.' 'I could be lying on the beach looking up at clouds.' This would appear to be a cognitive process.

(3) A further level of complexity occurred as a result of affective responses to the situation. 'An engine or a pneumatic drill. Boring into my head.' 'A blanket of cloud, it feels as though it's pressing down on me. A choking feeling.'

(4) Fully developed imagery in the visual modality. 'I can see the buildings quite clearly.' – 'It's our garden at home' could be categorized as eidetic, hypnagogic or hypnopompic. McKellar (1957) discusses these forms of imagery and gives estimates of their incidence in normal people.

(5) The somatic reports may well be of the same nature as the visual ones. It is also possible that civilized people are more used to responding to visual and auditory stimuli and therefore more capable of interpretation and discrimination in these modalities than in the sphere of motility. At the same time lack of movement, with its diminution of kinæsthetic feed-back, may place the organism in a 'deprived' state for the maintenance of body schema. Many subjects indeed found stillness intolerable – 'I'm going to move my feet just to make sure how I'm lying.' 'I've got the feeling that unless I move my hand I won't be sure it's still there.'

It is suggested that none of these responses could be classed as hallucinations in the strict

psychiatric sense, so that the results of this type of S.D. study are of only indirect relevance to psychiatry. The S.D. conditions, in fact, may not be crucial for the elicitation of similar reports and an obvious next step in investigation is to require introspections from subjects merely lying on a couch *without* either visual and/or auditory non-patterned input. It may be that appropriate conditions of set, attention and arousal are of equal importance.

Other Variables

No relationship was found in this study between reports of perceptual phenomena and age, sex, neuroticism or extraversion. Further work is, however, indicated, using larger and more representative samples with matching techniques and physiological measures. Similarly in the present data only the most tenuous association was found between reported experiences and responses to Galton's questionnaire on imagery. It would still seem to us, however, that a relationship may well exist between a subject's predominant imagery and the responses most readily elicited from him under S.D. conditions.

Several points may be stressed as being worth consideration in terms of future experimentation:

(1) Some subjects were familiar with this kind of auditory stimulus and found it easy to disregard; they tended not to report auditory imagery. Such subjects, all males, included the audiologist, an amateur electronics enthusiast and a man who had had experience of wireless operating. Others found the noise novel and distracting. They reported that its very intrusiveness inhibited the formation of any vivid auditory imagery.

Similarly many subjects reported that attention to one sense modality diminished their awareness of others.

(2) Tension, and with it heightened arousal levels, was only evident during the first few minutes of S.D. It is not surprising, therefore, that perceptual experiences were reported by the majority of subjects within ten minutes of being isolated. Anxiety when it occurred was initially high but in all except 2 cases tended to diminish. Although no subjects actually panicked 12 of them subsequently said that they could readily sympathize with anybody who found the S.D. situation intolerable.

(3) The relatively tense or anxious subjects reported more 'changes' of stimuli and affectively toned imagery. Their somæsthetic reports might well stem from misinterpretations of proprioceptive sensations due to tension. At the other extreme subjects who had difficulty in remaining awake reported imagery that was probably hypnagogic and hypnopompic. The tension referred to in the preceding paragraphs was presumably associated with increased cerebral vigilance and thus facilitated the detection of minute cues. Conversely the hypnagogic imagery of these more relaxed subjects might stem from diminished cerebral vigilance as discussed by Oswald (1962).

(4) Fully-developed imagery was invariably known to be such. Presumed stimulus 'changes' were, however, reported in many cases with complete confidence, in the belief that they had been controlled by the experimenter. The following are all examples from group A subjects: 'Nothing at all – except when you walked by and knocked the couch.' 'I had no bodily imagery whatsoever. The only experiences were real ones – as when you applied heat to my arm... Clever that – I suppose you used an electric blanket?' 'Nothing visual – not imagery, I mean. The only thing I noticed was the shadow. I suppose you'd moved between me and the lamp.' It is of psychiatric importance to note that when subjects were later informed that no intervention by the experimenter had in fact been made, they accepted this immediately, although with surprise.

(5) Just as the quality of imagery is related to affective state so test changes may be affected by anxiety. On the whole group B were more tense than group A before the S.D. situation. If anxiety may be regarded as a drive it may be that their pre-S.D. performance was more highly motivated than their post-S.D., less tense performance. Their Battery 1 results in fact may represent an artificially high level rather than their Battery 2 results an unusually low one.

(6) That S.D. conditions do have emotional concomitants apparently out of proportion to their face value is evinced by the after-effects shown by subjects. In 5 cases (4 of them in group B) the elevation of mood subsequent to 'release' from the S.D. situation was high enough to be termed elation, e.g. 'I don't know what it is – I just feel slap-happy. . . .' 'Everything seems brighter somehow.' Two of the Group A subjects on the other hand claimed to have enjoyed the sleepy isolation of S.D. and were almost aggressively exasperated when 'released'. e.g. 'I felt you were intruding – breaking in on me'. In every case subjects found excuses to visit the experimenter on the day subsequent to their session. Many sought each other out in order to discuss the experience and compare notes.

Summary

We have demonstrated successfully, we believe, that: (1) With normal subjects it is possible to elicit, in less than 40 minutes, most of the S.D. phenomena reported by investigators using many hours or days. (2) The types and degrees of experience reported by subjects are associated

with expectations or set, as are the subjects' affective responses to the S.D. situation. (3) In examining our data we have suggested that the phenomena are explicable in terms of known normal psychological mechanisms, and thus implied that the term 'hallucination' has been used too loosely in previous studies. Primarily, however, this has been a pilot study, the main value of which may have been in indicating further lines of investigation.

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